The Effect of University Fees on Applications, Attendance and Course Choice: Evidence from a Natural Experiment in the UK *

Filipa Sá†

May 17, 2017

Abstract

Over the past two decades, large changes have been introduced to the level of university fees in the UK, with significant variation across countries. This article exploits this variation to examine the effect of fees on university applications, attendance and course choice. It finds that applications decrease in response to higher fees with an elasticity of demand of about -0.4. Attendance also decreases. The reduction in applications and attendance is larger for courses with lower salaries and employment rates after graduation, for non-STEM subjects and for less selective universities.

Key words: tuition fees, university applications, university attendance, course choice

JEL Classification: I21, J24

*I thank Suzanne Campbell at the Universities and Colleges Admissions Service (UCAS) and Rebecca Hobbs at the Higher Education Statistics Agency (HESA) for providing the data used in this study and for answering my queries about the data. Financial support from a British Academy/Leverhulme Small Research Grant (reference SG122737) is gratefully acknowledged. I would also like to thank seminar participants at the 2015 Royal Economic Society conference, the 2015 Annual Congress of the European Economic Association, the University of Sheffield and Queen's University Belfast for helpful comments.

†King's College London, IZA and CEPR. Email: filipa.sa@kcl.ac.uk.

1 Introduction

The cost of a degree is an important determinant of the decision to apply to university. In the UK, there have been significant changes in the level of tuition fees in the last two decades, with substantial variation across countries. Before 1998, the cost of a university degree was entirely supported by the government. Since then, students in England have been asked to pay an increasingly larger share of the cost of higher education, while students in Scotland do not have to pay any tuition fees.

This article uses variation in tuition fees over time and across countries in the UK to study the effect of fees on university applications, attendance and course choice. I focus on the most recent and largest policy change: the increase in fees in England from £3,375 to a maximum of £9,000 per year in 2012.[1] This change in tuition fees is larger than most reforms previously studied for other countries. The very large magnitude of the reform, combined with the fact that it did not apply uniformly across all UK countries, makes this policy ideal for estimating the causal effect of tuition fees on applications and attendance.

The change in tuition fees was accompanied by other policy changes regarding student funding — changes in maintenance loans and grants were introduced for students from low-income families and the National Scholarship Programme (NSP) was introduced to widen participation. Because these changes in funding were implemented at the same time as the increase in tuition fees in England, the estimates in this paper cannot untangle the pure effect of fees from all other changes in policy that occurred simultaneously. Therefore, the results should be interpreted as identifying the causal effect of the increase in fees and accompanying changes to student funding.

I estimate a difference-in-differences (DD) model using administrative data on applications by English and Scottish students and on the number of undergraduates at English and Scottish universities. I find that the increase in fees (and accompanying changes in funding) introduced in England in 2012 reduced applications by 18.7% and reduced the number of first-year undergraduates by 10.9%. Because the increase in fees was pre-announced in October 2010, students may have decided to apply to university earlier to avoid paying higher fees. To test for anticipation effects, I estimate the model including leads and lags of the treatment indicator. I find no evidence of

[1] All figures reported in this article are expressed in nominal prices.

an anticipation effect for applications, but find an increase in attendance in 2011. This implies that the simple DD estimator for attendance should be interpreted with care, as Scotland may not provide a reliable counterfactual for what would have happened to attendance in England in the absence of treatment. The model with leads and lags of the treatment indicator controls for these different trends and provides a measure of the effect on attendance in 2012 and subsequent years.

Looking across different types of courses, I find that applications and attendance fell by more for courses that lead to lower salaries and lower employment rates after graduation. There is also evidence that STEM (science, technology, engineering and mathematics) courses and courses at more selective universities were less affected by the increase in fees. This suggests that applicants take expected future earnings and employment prospects into account when making their course choices. Faced with a higher level of debt, students choose courses that offer higher labour market returns after graduation. This implies that there is scope for tuition fees to vary by subject and institution to reflect this differential in students' willingness to pay across courses.

The use of applications data allows me to estimate the price elasticity of demand for higher education. Most previous studies on the effect of tuition fees on education outcomes focus on attendance rates. Attendance is an equilibrium outcome, determined by the demand and the supply of university places. While studies that focus on attendance rates confound the effect of fees on demand and supply, my analysis for applications isolates the demand effect. Using data for the entire period after the introduction of fees, I estimate a price elasticity of demand for higher education of -0.4.

To examine the importance of credit constraints in access to higher education, I use the level of participation in higher education by local authority as a measure of advantage and look at the effect of the increase in fees in 2012 on attendance for students from different backgrounds. I find that attendance fell by more for students from more advantaged backgrounds. This suggests that credit constraints do not play an important role in the decision to go to university in the UK, perhaps because student loans and policies adopted to widen participation — such as fee waivers, bursaries and maintenance grants — are effective in reducing the cost of higher education for low-income students.

I also examine the differential effect of the policy changes introduced in England in 2012 by ethnic group and gender. I find a larger reduction in attendance for white students and a larger reduction in both applications and attendance for women.

This article contributes to the literature on the effect of schooling costs on schooling outcomes. The typical identification challenge in this literature — discussed, for example, in Dynarski (2003) — is the fact that the cost of education is likely a function of omitted variables correlated with the demand for education. Institutional changes that introduce a discrete shift in the cost of education can induce variation that is uncorrelated with these unobserved determinants of schooling.

A number of studies use quasi-experimental methods to get around this issue. Most studies focus on the effect of tuition costs on enrollment. Deming and Dynarski (2009) review a number of studies for the US and find that most provide evidence that reducing college costs increases college entry and persistence. The evidence for other countries also points to a negative effect of tuition fees on enrollment. Neill (2009) uses the political party in power in Canadian provinces as an instrument for provincial tuition fees and finds a negative effect of fees on enrollment. Hübner (2012) uses the introduction of tuition fees in some German states in 2007 to design a natural experiment and also finds that tuition fees reduce enrollment, by a similar magnitude to the effects identified with US data. Nielsen et al (2010) look at the effect of a reform that increased the amount of study grants in Denmark in 1988. Using variation in the level of grants as a function of parental income, they find that the increase in grants had a positive effect on college enrollment, although the effect is smaller than in the US literature. Garibaldi et al (2012) examine a slightly different outcome — the probability of late graduation, i.e., completing a degree in more than four years. They use attendance data for Bocconi University and adopt a regression discontinuity design to exploit variation in the level of tuition as a function of parental income. Their findings suggest that an increase in tuition fees reduces the probability of late graduation.

For the UK, a limited number of studies use quasi-experimental methods to examine the effect of fees on university attendance. Crawford and Dearden (2010) compare attendance rates of English students living near Scotland and far from Scotland before and after the increase in fees in England in 2006. The intuition for this identification strategy is that English students attending university in Scotland still have to pay fees, but at a lower level than if they were attending university in England. The results suggest that the 2006 reform did not have a significant effect on participation. However, the authors attach little weight to these finding because participation trends prior to the reform appear different for the two groups of students. Dearden et al (2014) focus on the increase in grants for low-income families in England, Wales in Northern Ireland in 2004. They compare students from low and high income families and find that the increase in grants had a positive effect on participation.

While there is a large literature looking at the effect of schooling costs on attendance, few studies look at the effect on course choice. Rothstein and Rouse (2011) look at the effect of a "no-loans" policy introduced in a selective university in the US in the early 2000s. This policy replaced the loan component of financial aid awards with a grant. They find that students responded to the reduction in debt by choosing lower salary jobs, although they do not find an effect on the choice of major or on academic performance. In two related studies, Sjoquist and Winters (2015a and 2015b) look at the effect of financial aid on the probability of graduating from a STEM subject. They use variation in financial aid across US states and find that the adoption of a strong aid program had a negative effect on the number of STEM graduates.

To my knowledge, this article is the first to evaluate the effect of the large change in tuition fees that occurred in the UK in 2012 using quasi-experimental methods. It also adds to the existing literature in two other dimensions. First, it looks at applications in addition to attendance, which is the focus of most other studies. While attendance is an equilibrium outcome and is affected by supply constraints, applications have the advantage of capturing the true preferences of applicants and isolating the demand response. Second, it contributes to the relatively small literature on the effect of tuition fees on course choice.[2]

The rest of this article is organised as follows. The next section presents the institutional framework, summarising the main changes to tuition fees introduced in the UK in the last two decades. Section 3 presents a simple model which provides clear predictions about the effect of tuition fees on the decision to go to university for students with different levels of access to credit and for courses that lead to different salaries after graduation. Section 4 discusses the empirical methodology. Section 5 discusses the data and presents descriptive statistics. Empirical results are presented and discussed in Section 6 and Section 7 concludes.

[2] Another potentially interesting outcome is the dropout rate. In the UK, college dropout is low compared to other countries. Data from HEFCE (2013b) shows that the dropout rate of first-year students has been relatively constant at about 8% between 2005 and 2011. This compares with a dropout rate of 41% in the US in 2013 (NCES (2015)). Because the dropout rate in the UK is low, I do not study it as an outcome.

2 Institutional framework

2.1 Evolution of tuition fees across UK countries

University tuition fees were first introduced in all UK countries in September 1998. Fees were set at £1,000 per year, with the expectation that means testing would imply that one third of students would not pay any fees.[3] Since then, there have been several changes in the level of tuition fees, with important variation across countries. In 1999, a devolution government was established in Scotland. The new Scottish Parliament received separate legislative powers in many areas, including tuition fees. From its creation, the Scottish Parliament adopted a distinctively different policy regarding tuition fees from that followed in the rest of the UK.

Figure 1 shows a time line with the evolution of tuition fees in England and Scotland. In Scotland, tuition fees were replaced with an endowment scheme in 2001. Instead of paying fees upfront, Scottish-domiciled students were required to pay a total of £2,000 after graduation if their annual earnings exceeded £10,000. In 2007, the Scottish government went one step further and eliminated fees altogether for Scottish-domiciled students graduating on or after April 2007. Students at Scottish universities qualify for no tuition only if they have been living in Scotland for at least three years by the time they start university or if they have moved to Scotland for a reason other than study. Scottish-domiciled students attending university in England still have to pay tuition at the same rate as English-domiciled students.

England has also made changes to tuition fees since their first introduction in 1998. In 2004, it was announced that, from academic year 2006/07, upfront tuition fees of £1,000 per year would be replaced with variable fees to be paid after graduation if annual earnings exceeded £15,000. Universities had discretion over the amount of fees they charged, up to a maximum of £3,000 per year.[4] In 2010, the government announced that this cap would be raised to £9,000 per year for students entering university in academic year 2012/13. This announcement generated intense discontent among students and led to a number of public demonstrations.

Although universities have discretion over the amount of fees they charge, there is evidence

[3] Students were exempt from fees if their families earned less than £23,000 per year and were charged reduced fees on a sliding scale if their families earned between £23,000 and £35,000. Students whose families earned more than £35,000 were charged full fees.

[4] This limit increased slightly every year in line with inflation and was at £3,375 in 2011/12.

that most universities in England have increased their fees substantially in response to increases in the maximum tuition limit. According to Universities UK (2009), almost all higher education institutions in England chose to set fees at the £3,000 cap from 2006/07. Regarding the most recent reform, evidence from HEFCE (2013a) shows that, in 2012/13, 42 of 124 higher education institutions in England were charging the maximum level of fees of £9,000 and no institutions were charging less than £6,000. The sector average fee was £8,040 in 2012/13 and £8,507 in 2013/14.

Wales and Northern Ireland have also introduced changes to the level of tuition fees in recent years. In Wales, the cap on tuition fees was also increased to £9,000 in 2012, in line with England. However, the Welsh Assembly pays fee costs above £3,465 per year for Welsh students studying at any UK university. This implies that Welsh students did not face an increase in fees in 2012, regardless of where they attend university in the UK. In Northern Ireland, fees were capped at £3,465 in 2012 for Northern Irish students, but only if they attend university in their home country.

2.2 Student funding

Undergraduate students may obtain funding for maintenance costs and tuition fees through grants and loans. Funding is provided by the government-owned Student Loans Company (SLC). Tuition fee loans are available to all students, regardless of income and are repayable with interest. Maintenance loans are also repayable with interest and have two components: a non-financially assessed portion, which all students can receive; and an income-contingent portion. Maintenance grants are a function of household income and are non repayable. The level of support provided under these different forms of funding has changed over time, with significant changes introduced in England in 2012, when the cap on tuition fees increased. Table 1, from Crawford and Jin (2014), summarises these changes.

Looking at tuition fee loans, prior to 2012 students in England started repaying their loans once they earned more than £15,795 a year. From 2012, this threshold increased to £21,000. Repayments are made either until the loan is repaid in full or until a certain length of time has passed (25 years before 2012 and 30 years under the current system), after which any remaining debt is forgiven. The interest rate charged was equivalent to inflation before 2012, corresponding to a 0% interest rate in real terms. After 2012, interest accumulates at a real rate of 3% while studying and $0-3\%$ after graduation, depending on income. The increase in the earnings threshold in 2012 made the system more generous, but the increase in the interest rate made it less generous. Crawford and Jin (2014) analyse the impact of these changes on different groups of graduates. They conclude that, on average, students who start higher education from 2012/13 will leave university with substantially more debt and will take longer to clear their debt. However, lower-income graduates will actually repay less, because of the increase in the income threshold for loan repayments.

Maintenance grants in England became more generous in 2012, increasing from £2,906 to £3,250 for an annual household income of £25,000 or less. However, maintenance grants have since been scrapped and are not available for students who started university from 2016/17 onwards. Maintenance loans also became more generous for low-income students in England in 2012. In addition, the NSP was introduced in 2012 to give at least £3,000 to low-income students, in the form of bursaries, maintenance grants and fee waivers. As with maintenance grants, the NSP has now ended and is not available to undergraduates who started university from 2015/16 onwards.

The increase in fees in England in the last decade led to a significant change in the sources of funding used by students. Figure 2 reports the percentage of English-domiciled students studying full time at universities in England by funding source for payment of tuition fees. Until the increase in fees in 2006, the fraction of students who borrowed to cover the cost of tuition was about the same as the fraction who did not receive any financial support for payment of tuition fees. The increase in the cap on fees led to an increase in the fraction of students who pay their fees with loans and a reduction in the fraction of self-funded students. This trend continued and in 2014 the vast majority of students (81%) were borrowing to pay tuition fees.[5]

The average amount of debt of an English graduate on entry into repayment (including both tuition and maintenance loans) has also been increasing steadily over time and stood at £24,640 in 2016 (SLC (2016)). This is higher than the average annual salary of an English graduate working full time six months after graduation in 2014/15, which stood at £22,000 (HESA (2016)). By contrast, student debt in Scotland is much lower (at £10,500), because students do not have to pay fees and only borrow to cover maintenance costs.

[5] Figure 2 refers only to financial support for payment of tuition fees and not for living expenses. Many students take out maintenance loans. For example, in 2000, 81% of students had a maintenance loan and the take-up rate has remained high since then (Department for Education and Skills (2003 and subsequent releases)).

3 Theoretical Framework

The model presented in this section follows closely the one in Cameron and Taber (2004). It is used to derive predictions about the effect of tuition fees on university attendance for credit-constrained and unconstrained individuals and for courses with different expected salaries after graduation. These predictions are useful for understanding the results of the empirical analysis.

In period $t = 0$, individuals choose between two schooling levels: not going to university ($S = 0$) and going to university ($S = 1$). They enter the labour market at $t = 0$ if they do not go to university and at $t = 1$ if they go to university. The lifetime utility for schooling choice S is given by:

$$V_S = \sum_{t=0}^{\infty} \delta^t \frac{c_t^\gamma}{\gamma}$$

where c_t is consumption at time t, δ is the rate of time preference, and $\gamma \in (-\infty, 1)$ measures the curvature of the utility function. This specification of the utility function ignores non-pecuniary benefits of a university education.

Individuals select S to maximise lifetime utility:

$$S = \arg\max\{V_S | S \in \{0, 1\}$$

Heterogeneity in credit access is introduced by assuming that some individuals have to pay a higher interest rate to borrow while they are in college. I follow Cameron and Taber (2004) and assume that unconstrained individuals can borrow at the market rate $R_m = 1/\delta$ in any period, while constrained individuals can borrow at some rate $R > 1/\delta$ while in school and face the market rate R_m after they enter the labour market. Individuals who do not go to university do not have any credit constraints and face the market rate in all periods. This heterogeneity in interest rates during school years could reflect differences in the ability to collateralise loans with personal or family assets during school. I solve the model for credit-constrained individuals. The solution for unconstrained individuals can be obtained as a special case where $R = 1/\delta$.

The lifetime budget constraint for each schooling choice is given by:

$$\begin{aligned}\sum_{t=0}^{\infty}\delta^t c_t &\leq I_0 \text{ if } S=0\\ c_0+\frac{1}{R}\sum_{t=1}^{\infty}\delta^{t-1}c_t &\leq I_1 \text{ if } S=1\end{aligned}$$

where I_0 is the present value of income if the individual does not go to university; and I_1 is the present value of income if he goes to university, net of direct schooling costs.

The first order conditions for utility maximisation are given by:

$$\begin{aligned}c_t &= c_0,\ \forall t \text{ if } S=0\\ c_t &= c_0,\ \text{if } t=0 \text{ and } S=1\\ c_t &= (R\delta)^{\frac{1}{1-\gamma}}c_0,\ \text{if } t\geq 1 \text{ and } S=1\end{aligned}$$

Substituting these values in the budget constraint gives:

$$\begin{aligned}I_0 &= \frac{c_0}{1-\delta} \text{ if } S=0\\ I_1 &= c_0+(R\delta)^{\gamma/(1-\gamma)}[\delta/(1-\delta)]c_0 \text{ if } S=1\end{aligned}$$

Solving for c_0 as a function of I_S and inserting into the utility function gives the lifetime utility for each schooling choice:

$$\begin{aligned}V_0 &= \frac{I_0^\gamma[1/(1-\delta)]^{1-\gamma}}{\gamma}\\ V_1 &= \frac{I_1^\gamma\{1+(R\delta)^{\gamma/(1-\gamma)}[\delta/(1-\delta)]\}^{1-\gamma}}{\gamma}\end{aligned}$$

The present value of income (I_S) depends on the schooling choice. Individuals who do not go to university receive a wage w_{0t} in each period t. Individuals who go to university have zero earnings while studying and pay a direct cost τ, which includes tuition fees and maintenance costs. After graduation, they receive a wage w_{1t} in each period t. The present discounted value of income for each schooling choice is given by:

$$
\begin{aligned}
I_0 &= \sum_{t=0}^{\infty} \delta^t w_{0t} = W_0 \\
I_1 &= \frac{1}{R}\sum_{t=1}^{\infty} \delta^{t-1} w_{1t} - \tau = \frac{1}{R} W_1 - \tau
\end{aligned}
$$

where $W_0 \equiv \sum_{t=0}^{\infty} \delta^t w_{0t}$ is the present value of earnings for an individual who does not go to university, discounted to time $t = 0$ and $W_1 \equiv \sum_{t=1}^{\infty} \delta^{t-1} w_{1t}$ is the present value of earnings for an individual who goes to university, discounted to time $t = 1$.

Substituting in the lifetime utility values above gives:

$$
\begin{aligned}
V_0 &= \frac{W_0^{\gamma}[1/(1-\delta)]^{1-\gamma}}{\gamma} \\
V_1 &= \frac{[(W_1/R) - \tau]^{\gamma}\{1 + (R\delta)^{\gamma/(1-\gamma)}[\delta/(1-\delta)]\}^{1-\gamma}}{\gamma}
\end{aligned}
$$

An individual chooses to go to university if $D = V_1 - V_0 > 0$.

The model can be used to study how changes in tuition fees (τ) affect the decision to go to university:

$$\frac{\partial D}{\partial \tau} = \frac{\partial V_1}{\partial \tau} = -\frac{\gamma V_1}{I_1} < 0$$

Proposition 1 *An increase in tuition fees makes it less likely that an individual will choose to go to university.*

The effect of credit constraints on the decision to go to university is captured by the effect of changes in the interest rate R:

$$\frac{\partial D}{\partial R} = \frac{\partial V_1}{\partial R} = -\frac{\gamma V_1}{R I_1}(c_0 + \tau) < 0$$

Proposition 2 *An increase in credit constraints makes it less likely that an individual will choose to go to university.*

The model can also be used to study whether individuals with a higher R are more sensitive to changes in fees:

$$\frac{\partial^2 D}{\partial R \partial \tau} = -\frac{\gamma V_1}{R I_1^2}[(c_0 + \tau)(1-\gamma) + c_0 (R\delta)^{\gamma/(1-\gamma)} \frac{\delta}{1-\delta}] < 0$$

Proposition 3 *An increase in tuition fees reduces the value of going to university by more for individuals who are credit constrained.*

Cameron and Taber (2004) do not examine whether the effect of tuition fees on the decision to attend university depends on the present value of earnings of a university graduate (W_1). However, their model can be easily used to analyse this differential effect:

$$\frac{\partial^2 D}{\partial W_1 \partial \tau} = \frac{\gamma V_1}{R I_1^2}(1-\gamma) > 0$$

Proposition 4 *An increase in tuition fees reduces the value of going to university by less for courses that lead to higher salaries after graduation.*

4 Empirical Methodology

The causal effect of tuition fees on schooling decisions is identified through variation in the level of fees in England and Scotland over time. In the baseline analysis, I focus on the increase in the cap on tuition fees and accompanying changes in funding introduced in England in 2012. The increase in the cap on fees raised the tuition cost of a degree from just over £10,000 to £27,000, for students at universities that charge maximum fees. As a robustness check, I estimate a more general fixed effects model, which considers all changes in tuition fees introduced in both countries since 1998.

The baseline analysis is based on the following difference-in-differences model:

$$\ln(y_{djt}) = \gamma_d + \lambda_t + \delta D_{dt} + X'_{djt}\beta + \varepsilon_{djt} \tag{1}$$

where d denotes country of domicile, j denotes gender, age group, institution and subject group (as described in the data section) and t denotes year. The dependent variable is the log of the number of university applications or the log of the number of first-year undergraduates. The model includes country of domicile fixed effects (γ_d) and year fixed effects (λ_t). The vector of controls

(X_{djt}) includes dummies for gender and age group and the log of population living in country d, in gender and age group j in year t. The regressor of interest is D_{dt} and indicates observations for students who lived in England before they started university (treatment group) in the period after the change. For applications data, the post-treatment period goes from 2012 to 2015. For attendance data, it goes from 2012 to 2014. The pre-treatment period goes from 2008 to 2011. The analysis starts in 2008 to isolate the effect of the increase in fees in England in 2012. Because Scotland removed fees in 2007, extending the analysis to the period before 2008 would capture the effect of that change as well. However, I will also present the results of a fixed effects model estimated on the full set of data (from 1998 to 2015), which captures the effect of all different fee changes that occurred in England and Scotland during this period.

The causal effect of the increase in tuition fees and accompanying changes in funding that were implemented in England in 2012 is captured by δ and can be interpreted as the change (in log points) in the number of applications or students induced by the policy changes. The specification controls for changes over time in the dependent variable and for average differences between students from Scotland and from England. The key identifying assumption is that trends in the dependent variable would have been the same for English and Scottish students in the absence of the policy changes. The policy changes introduced in England in 2012 induce a deviation from this common trend, which is measured by the DD estimator. Although the log level of applications or the log level of the number of first-year undergraduate students in England and Scotland may be different, this difference should be captured by the country of domicile fixed effects (γ_d).

To check the common trends assumption, I add country-specific time trends in equation (1) and estimate:

$$\ln(y_{djt}) = \gamma_{0d} + \gamma_{1d}t + \lambda_t + \delta D_{dt} + X'_{djt}\beta + \varepsilon_{djt} \qquad (2)$$

where γ_{0d} is a country-specific intercept, as before, and γ_{1d} is a country-specific trend coefficient multiplying the time trend variable t.

An important feature of the UK tuition fee system is that students at Scottish institutions only qualify for no tuition if they have been living in Scotland for at least three years by the time they start university or if they have moved to Scotland for a reason other than study. English students who move to Scotland to attend university still have to pay tuition fees. This is important because it reduces the potential for selection bias. If students were able to qualify for no fees simply by going to university in Scotland, we would probably observe that those who move to Scotland are more likely to go to university, i.e. there would be a negative selection bias in the DD estimator. The requirement that a student must have lived in Scotland for at least three years to qualify for no tuition implies that membership of the treatment and control groups is arguably unrelated to individual choices.[6]

Scottish-domiciled students still have to pay higher tuition fees if they decide to go to university in England. This implies that some students assigned to the control group actually receive treatment. In the language of experiments, δ captures the intention-to-treat effect. In practice, however, the vast majority of Scottish and English students apply to university in their home countries. Figure 3 reports the share of applications to universities in the applicant's home country. While the vast majority of English and Scottish students apply to university in their home country, many Irish and Welsh students apply to study elsewhere in the UK (mostly in England). Because my analysis focuses on England and Scotland, the coefficient δ is a close approximation of the effect of the treatment on the treated.

Figure 3 also suggests that the share of Scottish students who apply to university in Scotland increased slightly after 2012. This is a natural response to the increase in the cap on fees in England in that year. This does not invalidate the use of Scottish-domiciled students as a control group, because the classification of students into treatment and control groups is based on country of domicile and not on where they decide to attend university. The increase in fees in England in 2012 may have affected the decision of Scottish students of *where* they attend university, but they are still a suitable control group as long as the policy change did not affect their decision of *whether* to apply or not. There is no reason to believe that their decision of whether to apply or not would have been affected, since Scottish students still have the option of paying no fees by attending university in Scotland.

To account for correlation in the error terms, I report heteroskedasticity-robust standard errors

[6] The mobility response of students to changes in fees is studied, for example, in Dwenger et al (2012). The authors design a natural experiment by exploiting changes in tuition fees across German states. Using administrative data on applications to medical school, they find that students are less likely to apply to universities in their home state after the introduction of fees.

clustered by country. These standard errors are robust to arbitrary forms of error correlation within a country. As emphasised in Moulton (1986) and Bertrand, Duflo and Mullainathan (2004), ignoring such clustering can greatly underestimate the true OLS standard errors. A practical limitation of inference in my study is the small number of clusters, as there are only two countries in the analysis. In this situation, standard errors tend to be too small, as discussed in Cameron and Miller (2015). To account for this, Stata uses a small-sample correction and forms critical values using a T-distribution with $G - 1$ degrees of freedom, where G is the number of clusters. This adjustment improves inference, although there may still be some degree of overrejection.[7]

5 Data and Descriptive Statistics

Data on applications were produced on request by the Universities and Colleges Admissions Service (UCAS), which manages all applications to undergraduate courses in the UK. The information provided is the total number of applications to English and Scottish universities by country of domicile (England and Scotland), institution (156 universities and colleges), gender, age group (18 years and under, 19, 20, and 21 and over), and subject (16 categories), for the period from 1998 to 2015. Applicants are allowed to make more than one application to university. Until 2007, each applicant could apply to up to six courses. From 2008, the maximum number of choices was reduced to five. Because this change applied both to England and Scotland, it is absorbed by year fixed effects.[8]

Data on the number of first-year undergraduate students were obtained from the Higher Education Statistics Agency (HESA) via the Heidi portal and cover the entire population of first-year undergraduates for the period from 2002 to 2014. The data are disaggregated at the same level as the data from UCAS.[9] In addition, they contain information on ethnicity (white, Asian, black and other) and the local authority where the student was domiciled before going to university. I use this additional information to test whether the increase in fees in England in 2012 had a larger

[7] Because of this adjustment, the significance values reported in the tables may not match the ones that would be obtained if the critical values had been calculated assuming a standard normal distribution of the Wald t-statistic.

[8] Data from UCAS shows that the number of applications per applicant fell from 4.4 to 3.7 in 2008. Apart from that year, the number of applications per applicant has been broadly constant in the periods before and after 2008. This implies that the results that I obtain for applications should also provide information about the effect of tuition fees on the number of applicants.

[9] To protect confidentiality of the data, cell counts in UCAS and HESA data are rounded to the nearest 5, with cell counts below 3 reported as missing.

negative effect on students from minority groups or from local areas with low rates of participation in higher education. Information on rates of participation in higher education by local authority is obtained from the Higher Education Funding Council for England (HEFCE) and is known as POLAR 3. The numbers used measure rates of participation in higher education for people who reached age 18 between 2005 and 2009.

To analyse the differential effect of tuition fees across courses, I combine administrative data on applications with data on salaries and employment rates after graduation from the HESA Destinations of Leavers from Higher Education (DLHE) survey. The survey covers the universe of all graduates who were domiciled in the UK prior to attaining higher education (with a response rate of 75%) and is conducted six months after graduation. It provides information on the activity of first-degree graduates: in full-time paid employment (including self-employment), in part-time paid employment, in voluntary/unpaid employment, in further study and assumed to be unemployed. It also reports the salaries of graduates in full-time paid employment and contains information on age, gender, institution and subject. I use data for students who graduated in 2011/12 and calculate average salaries and average employment rates by gender, institution and subject. To reduce the effect of outliers, average salaries are calculated for workers age 20 to 30 earning less than £60,000 per year. The employment rate is defined as the share of the population of graduates in full-time paid employment six months after graduation.

The model controls for the log of population by country, year, gender, and age group (obtained from the Office for National Statistics mid-year population estimates). Between 1998 and 2015, population aged 17 to 24 increased by 18.9% in England, compared with 10.7% in Scotland. This should lead to a relative increase in applications and attendance by English-domiciled students, regardless of the level of tuition fees. I account for this by controlling for population in the model.

The common trends assumption is investigated in Figures 4 and 5. Figure 4 shows the evolution in the log number of applications in England and Scotland and Figure 5 shows the evolution in the log number of first–year undergraduates in both countries. The graphs on the left distinguish between STEM and non-STEM subjects and the graphs on the right distinguish between selective universities and other universities.[10] The figures report data from the earliest available year to

[10] Selective universities are the ones in the Sutton Trust 30 group: Bath, Birmingham, Bristol, Cambridge, Durham, Edinburgh, Exeter, Glasgow, Imperial College, King's College London, Lancaster, Leeds, Leicester, Liverpool, London School of Economics, Manchester, Newcastle, Nottingham, Oxford, Reading, Royal Holloway, Sheffield, Southampton,

give a better sense of the underlying trends. However, because the difference-in-differences model is estimated on data from 2008 onwards, the validity of the DD estimator relies on the assumption that applications and attendance in England and Scotland followed a common trend between 2008 and 2011.

Applications followed an upward trend in England and Scotland between 2008 and 2011 and then dropped in England in 2012, when tuition fees were raised. The drop was more pronounced for applications to non-STEM subjects and to less selective universities. Applications by English-domiciled students recover post-2012, especially for STEM subjects and selective universities.

Figure 5 shows that, as for applications, the number of first-year undergraduate students in England also dropped in 2012, especially for non-STEM subjects and for less selective universities. Again, the effect for selective universities and STEM subjects appears to be temporary, with the number of first-year undergraduates recovering in 2013 and 2014. For less selective universities and non-STEM subjects, student numbers in 2014 remained below their pre-2012 trend.

These figures support the assumption of common trends and suggest that changes in fees have induced a deviation from the trend. They provide suggestive evidence that higher tuition fees discourage university applications and attendance, with important differences across subjects and universities.

To provide a more complete picture of the evolution of applications and attendance by country of domicile, Table 2 reports the (log) number of applications and first-year students by country of domicile. It also calculates the change in log applications and log attendance between 2011 and the latest available year (2015 for UCAS data and 2014 for HESA data). The table shows a clear decline in applications in England in 2012. Application numbers have since recovered, but remained below their 2011 level in 2015. At the same time, applications in Scotland have been increasing. Looking at attendance, there is also a clear decrease in 2012. Student numbers recovered in 2013 and 2014, but remained below their 2011 level. In Scotland, the number of first-year students was broadly constant between 2011 and 2014.

In the next section, I go beyond descriptive statistics and use regional variation in the level of fees to measure the causal effect of the policy changes introduced in England in 2012 on applications and attendance. I also provide two formal checks of the common trends assumption, as suggested

St Andrews, Strathclyde, Surrey, University College London, Warwick and York.

in Angrist and Pischke (2009). First, I test the robustness of the DD coefficients to the inclusion of country-specific trends in the model. Second, I implement a test for causality in the spirit of Granger (1969) and include leads and lags of the reform indicator.

6 Results

6.1 Initial estimates

The first three columns in Table 3 report the results with the log of university applications as the dependent variable. The results suggest that the increase in tuition fees and accompanying changes in funding in England in 2012 reduced applications by 20.7 log points (26.3 in the model with country-specific time trends). This is equivalent to a reduction in applications by between 18.7% and 23.1%. The last two columns in Table 3 report the results with the log of the number of first-year undergraduates as the dependent variable. Attendance decreased by 11.5 log points (19.7 in the model with country-specific time trends), which is equivalent to a reduction by between 10.9% and 17.9%. It is reassuring that the results are robust to the inclusion of country-specific trends, suggesting that the common trends assumption is reasonable.

These findings support the prediction of the theoretical model discussed in Section 3 that an increase in tuition fees makes it less likely that an individual will choose to go to university. However, these results should be interpreted with some caution because, as discussed in Section 2, the increase in tuition fees in England in 2012 was not the only policy change that occurred in that year. Changes in maintenance loans and grants were also introduced for students from low-income families and the NSP was introduced to widen participation. As a result, the actual level of fees for students from low-income families would have been lower than the headline price of £9,000. The DD estimates capture the effect of all changes to fees and funding that occurred in England in 2012, and not the change in fees alone. Section 6.4 presents results for attendance rates across local authorities with different rates of participation in higher education. Because education is correlated with income, those results illustrate whether the increase in fees had a larger effect on high-income students than on low-income students, who benefited from more generous maintenance loans and grants and from the NSP.

With this caveat in mind, it is useful to think about what the DD estimates would mean if the effect was attributed only to the increase in fees in England. Although this is not an entirely accurate interpretation, it helps benchmark the results against other findings in the literature. The DD coefficient for applications can be expressed in terms of price elasticity of demand for higher education. The 2012 reform increased the cost of a degree from just over £10,000 to £27,000 at institutions that charge maximum fees. A reduction in applications by 20.7 log points implies an elasticity of applications with respect to fees of -0.11.

The DD coefficient for attendance is easier to benchmark against other studies, because most of the literature focuses on the effect of college costs on attendance rates, rather than applications. Deming and Dynarski (2009) summarise the findings of a number of quasi-experimental studies conducted for the US and report that an increase in student subsidies to higher education by $1,000 increases the college attendance rate by between 3 and 5 percentage points. This is equivalent to an increase of 5 to 8 percentage points for a £1,000 increase in subsidies.[11] Using UK data, Dearden et al (2014) find a slightly smaller effect, with an increase of 3.95 percentage points in the participation rate for a £1,000 increase in student grants. The 2012 reform increased the cost of a degree by £17,000 and reduced the number of first-year students by between 11.5 and 19.7 log points. This corresponds to a reduction in the number of first-year students of between 0.6% to 1% for a £1,000 increase in fees. Evaluated at an attendance rate of 23% for 18 year-olds in 2010/11 (BIS (2014)), a 1% reduction is equivalent to a reduction of only 0.23 percentage points in the attendance rate for a £1,000 increase in fees. Although the 2012 reform had a large overall effect on attendance, the change in fees was also very large. As a result, the effect measured per £1,000 is smaller than that found in previous studies.

6.2 Anticipation effects

The increase in the cap on fees in 2012 was pre-announced in October 2010. This pre-announcement may have affected the decision of when to apply to university. In particular, it is possible that students who were deciding whether to take a gap year or apply to university in 2011, decided to apply early to avoid paying higher fees. This would imply that part of the decline in applications observed in 2012 could be explained by an earlier increase in applications.

The possibility of anticipation effects was discussed by some commentators and policy reports at

[11] Conversion using the 2014 end-of-year spot exchange rate reported by the Bank of England.

the time of the fee increase in England. For example, the report of the Independent Commission of Fees (ICOF (2012)) looks at data from UCAS for the 2012 application cycle to study the impact of the increase in fees in England. This report reveals that there was no indication in 2011 that more 18 year-olds were applying during that cycle rather than taking a gap year and applying at age 19 in 2012. Analysis by UCAS at the time of the fee increase (UCAS (2012a) and UCAS (2012b)) comes to the same conclusion that there is no indication of any above trend increase in application rates in 2011 for 18 year-olds. Interestingly, when looking at the acceptance rate — defined as the share of applicants that have been placed for entry into higher education at the end of the cycle — the evidence in UCAS (2012b) shows an increase in 2011 for 18 year-olds. Therefore, we would expect to see evidence of anticipation effects for attendance.

To test for anticipation effects, I extend the model by including leads and lags of the reform indicator. This approach is similar to the one adopted in Autor (2003) to study the dynamic effects of employment protection on the use of temporary help workers. The coefficients on the leads and lags of the reform indicator are reported in columns (3) and (6) of Table 3. For applications, there is no evidence of anticipation effects, since the coefficients on the interaction of the treatment indicator with the indicators for the two years before the reform are insignificant. This finding provides further evidence in favour of the common trends assumption. For attendance, anticipation effects are more apparent — attendance increased in 2011 by 7.4 log points, followed by a decline by 13.3 log points in 2012, which is consistent with the suggestive evidence for acceptance rates in UCAS (2012b). Looking at Figure 5 and Table 2, it appears that attendance decreased in Scotland in 2011, which explains the positive coefficient on Treatment group $\times$ 2011. It also explains why the DD coefficient is slightly more negative after controlling for country-specific trends, since it takes into account the fact that attendance in Scotland was falling just before 2012. The finding of an anticipation effect for attendance suggests that the simple DD coefficient reported in column (4) of Table 3 should be interpreted with care, since the common trends assumption does not hold. The effect on attendance should instead be measured by the coefficients on the interaction of the treatment indicator with the post 2012 dummies, reported in column (6).

The results on the interaction of the treatment indicator with the post-2012 years suggest that applications in England remained relatively low in 2015, although the negative effect is smaller in 2014 and 2015 than at the time of the increase in fees. Attendance numbers in 2014 were also still lower than they would have been in the absence of the increase in fees. The negative effect of the increase in fees appears to be gradually decreasing, with both applications and attendance recovering since 2012, but is had not disappeared completely by 2015.

6.3 Heterogeneity across courses

One prediction of the theoretical model discussed in Section 3 is that changes in tuition fees should have a larger effect on applications and attendance for courses that lead to lower wages after graduation. To test this hypothesis, I combine data on average salaries and employment rates after graduation by gender, institution and subject group with applications and attendance data and study the effect of the increase in fees in England in 2012 at different quartiles of the distribution of expected future salaries and employment rates.

Table 4 reports average salaries and employment rates by subject for students who graduated in academic year 2011/12. The table reveals a large heterogeneity in average salaries and employment rates across subjects. Graduates in medicine and dentistry have the highest annual average salary (at almost £29,000) and also the highest employment rate (at 92%). Graduates in creative arts and design have the lowest annual average salary (at just over £16,000) and graduates in law have the lowest employment rate (at 35%).[12] The table also shows that there is variation in salaries across institutions, with graduates from selective universities earning over £3,000 a year more than those from other universities, but employment rates are similar for both groups of graduates.

To test how the increase in fees and accompanying changes in funding have affected applications and attendance along the distribution of expected salaries and employment rates, I use data on average salaries and employment rates six months after graduation for cells defined by subject $\times$ institution $\times$ gender. These data are from the 2011/12 HESA Destinations of Leavers from Higher Education (DLHE) survey. I then take the distribution of all these observations and calculate the quartiles of this distribution. Finally, I estimate the model including an indicator for each quartile and interactions of these indicators with the treatment variable (D_{dt} in model (1)).

The results, reported in Table 5, suggest that the policy changes introduced in England in 2012 reduced applications and attendance by more for courses in the bottom two quartiles of the distribution of expected salaries. Applications to courses in the bottom two quartiles of the salary

[12] The ranking of salaries across subjects is similar to the one reported in Chevalier (2011).

distribution decreased by 25 log points, compared with 11.4 log points for courses in the top quartile. Attendance fell by 16.3 log points for quartile 1 and 20.9 log points for quartile 2, compared with 11.9 log points for the top quartile. A similar pattern is found when looking at employment rates, although the results are less precise. I find a larger negative effect for courses that lead to lower salaries after graduation despite the fact that students who borrow to pay tuition fees only start repaying their loans when their annual earnings reach £21,000. Without this design feature of the student loans system, I would expect higher tuition fees to have an even larger negative effect on applications and attendance for courses with poor job prospects.

The analysis by salary and employment quartiles combines two types of choices that applicants make: the choice of subject and the choice of institution. To try to separate these two aspects, I analyse the differential effect of the policy changes for STEM and non-STEM subjects and for more and less selective universities. Because STEM graduates and graduates from selective universities tend to have higher salaries, I would expect applications and attendance to be less affected by the increase in fees for these two groups. The results, reported in Table 6, show a much larger reduction in applications to non-STEM subjects following the increase in fees in England in 2012. Looking across institutions, there is evidence of a larger effect on applications to less selective universities, although the results are less precise. The results for attendance tell a similar story and show a larger reduction in the number of first-year undergraduates attending non-STEM courses and less selective universities.[13]

These findings are consistent with the predictions of the theoretical model and suggest that students take expected future earnings and employment prospects into account when making their course choices. They are also consistent with the results in Chevalier (2011). He reports large differences in earnings by subject and calculates a graduate tax — in the form of tuition fees — that captures these subject wage premia. His results suggest that there is some scope for charging subject-specific fees. My findings indicate that students are indeed willing to pay higher fees for institutions and subjects that lead to better employment prospects after graduation. The finding

[13] I have also adopted an alternative method to separate the choice of subject and the choice of institution. To isolate the effect on the choice of institution, given the subject, I look at the effect on applications and attendance for different quartiles of the distribution of wages and employment for cells defined by subject × gender. To isolate the effect on the choice of subject, given the institution, I calculate the quartiles for cells defined by institution × gender. The results (available on request) are consistent with the prediction of the theoretical model and show a larger negative effect on applications and attendance for institutions and subjects that lead to lower salaries and employment rates after graduation.

of a larger negative effect on applications and attendance for non-STEM subjects is consistent with the evidence in Sjoquist and Winters (2015a), which shows that the adoption of merit programs by some US states reduced the likelihood of graduating with a STEM degree.

6.4 Heterogeneity across a geographic measure of advantage

To test whether students from different backgrounds are affected differently by the increase in tuition fees, I use administrative data from HESA on the number of first-year undergraduates by local authorities with different levels of participation in higher education. This measure of advantage is commonly used in policy reports. UCAS analysis at the time of the increase in fees (UCAS (2012a)) suggests that application rates for 18 year-olds from more advantaged backgrounds — defined as local areas with higher rates of participation in higher education — fell by more between 2011 and 2012 than those from less advantaged backgrounds.

The theoretical model discussed in Section 3 predicts that an increase in tuition fees should have a larger effect on applications and attendance for credit constrained students. In the model, credit constraints are captured by a higher interest rate during school years, which could reflect differences in the ability to collateralise loans with personal or family assets. Because my data do not contain a direct measure of income or wealth, I use the local area's rate of participation in higher education as a proxy.[14]

Table 7 reports the results of estimating model (1) separately for local authorities with low and high participation in higher education. Local authorities are divided into two groups by the median rate of participation in higher education of people who reached age 18 between 2005 and 2009.[15] The results show that attendance fell by more for students from local authorities with higher rates of participation in higher education, which is consistent with the evidence in UCAS (2012a).

These results are not surprising because the government provides tuition fee loans to all students on similar terms. Students from low-income families have also until recently benefited from more generous maintenance grants and from fair access schemes provided in the context of the NSP.[16]

[14] The rate of participation in higher education (from HEFCE POLAR 3) is strongly correlated with the fraction of the population by local authority in managerial or professional occupations (from the 2011 Census), with a correlation coefficient of 0.86. This implies that there should be a good correlation between participation in higher education and income. Therefore, this geographic measure of advantage should also capture credit constraints.

[15] To avoid small cell counts, data disaggregated by local authority are not disaggregated by subject.

[16] Universities that change tuition fees above £6,000 need to have an access agreement approved by the Office for Fair Access, setting out the measures that they have adopted to improve access for students from less advantaged

These forms of support appear to have been effective in relaxing credit constraints. These findings are consistent with evidence in Carneiro and Heckman (2002), who find that only a small proportion (up to 8%) of the US population were credit constrained in their decision to attend college. Dearden at al (2004) apply the same methodology to UK data and also find no evidence of significant credit constraints in access to higher education.

6.5 Heterogeneity across ethnic groups and gender

The theoretical model discussed in Section 3 does not make any direct predictions about whether the response of applications and attendance to an increase in fees differs by ethnicity and gender. Nonetheless, it is interesting to test whether such differences are present in the data. To investigate this, I estimate model (1) separately by ethnic group and gender. For ethnicity, I only study the effect on attendance, since the data that I have collected for applications do not provide this type of disaggregation.

The results by ethnic group are reported in Table 8 and show that the increase in fees and accompanying changes in funding introduced in England in 2012 reduced attendance of white students by 33.3 log points (equivalent to 28.3%), with a much smaller effect for other ethnic groups. The results by gender — reported in Table 9 — suggest a larger negative effect on applications and attendance for women than for men.

6.6 A more general approach

The many changes in tuition fees that occurred in England and Scotland in the last two decades provide multiple "experiments". So far, I have focused on the increase in fees in England in 2012. In this section, I estimate a more general fixed effects model which uses information about the level of tuition fees in both countries across all years:

$$\ln(y_{djt}) = \gamma_d + \lambda_t + \delta \ln Fees_{dt} + X_{djt}^{'}\beta + \varepsilon_{djt} \tag{3}$$

The dependent variable is the log of the number of university applications and the main regressor of interest ($lnFees_{dt}$) is now the log level of tuition fees in country d at time t. All other variables

backgrounds.

are the same as in model (1). The model is estimated for the full period after the introduction of tuition fees — 1998 to 2015 — and is specified in logs to allow interpretation of δ as the price elasticity of demand for higher education. This coefficient has a causal interpretation if the level of tuition fees is exogenously determined and not a function of omitted variables correlated with the demand for education. In the UK context, this assumption is not implausible because changes in the level of fees have been mostly driven by political events, such as devolution in Scotland and changes in government in England.

To analyse the differential effect of tuition fees across types of subjects, I extend the model to include an interaction between the log level of fees and an indicator for STEM subjects. Similarly, to analyse the differential effect across institutions, I include an interaction between the log level of fees and an indicator for selective universities. The results, reported in Table 10, suggest an elasticity of demand with respect to fees of -0.356, which is larger than the elasticity found for the 2012 reform alone (-0.11). However, in the full sample applications to non-STEM subjects and to less selective universities no longer appear to be more sensitive to changes in fees. Perhaps applicants are more strategic about their choice of course after 2012 because of the large magnitude of the increase in fees.

7 Conclusions

The level of university fees in the UK has changed significantly in the last two decades, with substantial variation across countries. This article exploits this variation to design a natural experiment and estimate the causal effect of tuition fees on applications, attendance and course choice. It focuses on the increase in fees in England in 2012, which almost tripled the cost of a university degree. This is a very large policy change when compared with previous reforms in the UK and with reforms studied for other countries.

Using administrative data on applications and attendance, I find that the increase in fees and accompanying changes in funding introduced in 2012 reduced applications by 18.7% and reduced the number of first-year undergraduates by 10.9%. Behind this overall effect, there are important differences by course. Courses with lower expected salaries and employment rates after graduation were more affected by the increase in fees. Looking across subjects and institutions, applications and attendance fell by more for non-STEM subjects and for less selective universities.

To examine the importance of credit constraints, I look at the effect on attendance for local authorities with different rates of participation in higher education. I find that the increase in fees reduced attendance by more for students from local authorities with higher rates of participation in higher education. This suggests that credit constraints do not play a significant role in the decision to attend university. Looking across different ethnic groups, I find that attendance decreased by more for white students. I also find some differences by gender, with applications and attendance falling by more for women than for men.

These results have important implications for future higher education policy.

The differential effects across subjects and institutions suggest that, faced with higher fees and a higher level of debt, students choose courses that offer better employment prospects and allow them pay off debt more quickly after graduation. They also suggest that there is scope for fees to vary across subjects and institutions to reflect this differential in students' willingness to pay.

The findings that attendance fell by more for students from local authorities with higher rates of participation in higher education and for white students suggest that the increase in fees did not discourage students from disadvantaged backgrounds from applying to university. These results may be explained by the particular institutional context in England, where all students are given access to government loans to pay their fees and universities are required to adopt policies to improve access for students from disadvantaged backgrounds. When considering future increases in fees, policymakers should continue to ensure that funding policies are in place to provide support to students from low-income families.

The results by gender suggest that future fee increases may have a larger impact on women than on men and may potentially be seen as discriminatory. Policymakers should take these heterogeneous effects into account when considering further increases in fees.

References

Angrist, J. and Pischke, J.-S. (2009). *Mostly Harmless Econometrics: An Empiricist's Companion*, Princeton University Press, Princeton New Jersey.

Autor, D. H. (2003). 'Outsourcing at Will: The Contribution of Unjust Dismissal Doctrine to the Growth of Employment Outsourcing', *Journal of Labor Economics*, vol. 21(1), pp. 1-42.

Bertrand, M., Duflo, E. and Mullainathan, S. (2004). 'How Much Should We Trust Difference-in-Differences Estimates?', *The Quarterly Journal of Economics*, vol. 119(1), pp. 249-75.

BIS (2014). 'Participation Rates in Higher Education: Academic Years 2006/07 - 2012/13', Department for Business, Innovation & Skills Statistical First Release August 2014.

Cameron, S. V. and Taber, C. (2004). 'Estimation of Educational Borrowing Constraints Using Returns to Schooling', *Journal of Political Economy*, vol. 112(1), pp. 132-82.

Cameron, A. C. and Miller, D. L. (2015). 'A Practitioner's Guide to Cluster-Robust Inference', *Journal of Human Resources*, vol. 50(2), pp. 317-72.

Carneiro, P. and Heckman, J. (2002). 'The Evidence on Credit Constraints in Post-secondary Schooling', *Economic Journal*, vol. 112(482), pp. 705-34.

Chevalier, A. (2011). 'Subject Choice and Earnings of UK Graduates', *Economics of Education Review*, vol. 30(6), pp. 1187– 1201.

Crawford, C. and Dearden, L. (2010). 'The Impact of the 2006-07 HE Finance Reforms on HE Participation', BIS Research Paper no. 13.

Crawford, C. and Jin, W. (2014). 'Payback Time? Student Debt and Loan Repayments: What Will the 2012 Reforms Mean for Graduates?', Institute for Fiscal Studies Report R93.

Dearden, L., McGranahan, L. and Sianesi, B. (2004). 'The Role of Credit Constraints in Educational Choices: Evidence from the NCDS and BCS70', Centre for the Economics of Education DP 48.

Dearden, L., Fitzsimons, E. and Wyness, G. (2014). 'Money for Nothing: Estimating the Impact of Student Aid on Participation in Higher Education', *Economics of Education Review*, vol. 43, pp. 66-78.

Deming D. J. and Dynarski, S. M. (2010). ‘Into College, out of Poverty? Policies to Increase the Postsecondary Attainment of the Poor’, in (P. Levine and D. Zimmerman, eds.), *Targeting investments in children: fighting poverty when resources are limited*, pp. 283-302, Chicago: University of Chicago Press.

Department for Education and Skills (2003). ‘Student Support: Statistics of Student Support for Higher Education in England and Wales, Academic Year 2001/2002’, London: National Statistics.

Dwenger, N., Storck, J. and Wrohlich, K. (2012). ‘Do Tuition Fees Affect the Mobility of University Applicants? Evidence from a Natural Experiment’, *Economics of Education Review*, vol. 31, pp. 155-167.

Dynarski, S. M. (2003). ‘Does Aid Matter? Measuring the Effect of Student Aid on College Attendance and Completion’, *American Economic Review*, vol. 93(1), pp. 279-288.

Garibaldi, P., Giavazzi, F., Ichino, A. and Rettore, E. (2012). ‘College Cost and Time to Complete a Degree: Evidence from Tuition Discontinuities’, *Review of Economics and Statistics*, vol. 94(3), pp. 699-711.

Granger, C.W J. (1969). ‘Investigating Causal Relations by Econometric Models and Cross-spectral Methods’, *Econometrica*, vol. 37(3), pp. 424-438.

HEFCE (2013a). ‘Higher Education in England: Impact of the 2012 Reforms’, Higher Education Funding Council for England report 2013/03.

HEFCE (2013b). ‘Non-Continuation Rates at English HEIs: Trends for Entrants 2005-06 to 2010-11’, Higher Education Funding Council for England issues paper April 2013/07.

HESA (2016). ‘Destinations of Leavers from Higher Education in the United Kingdom for the Academic Year 2014/15’, Higher Education Statistics Agency statistical first release SFR 237.

Hübner, M. (2012). ‘Do Tuition Fees Affect Enrollment Behavior? Evidence from a ‘Natural Experiment’ in Germany’, *Economics of Education Review*, vol. 31(6), pp. 949– 960.

Independent Commission on Fees (2012). ‘Analysis of UCAS Applications for 2012/13 Admissions’.

Moulton, B. (1986). 'Random Group Effects and the Precision of Regression Estimates', *Journal of Econometrics*, vol. 32(3), pp. 385-397.

NCES (2015). 'The Condition of Education: Institutional Retention and Graduation Rates for Undergraduate Students', U.S. Department of Education, National Center for Education Statistics, NCES 2015-144.

Neill, C. (2009). 'Tuition Fees and the Demand for University Places', *Economics of Education Review*, vol. 28(5), pp. 561–570.

Nielsen, H. S., Sϕrensen, T. and Taber, C. (2010). 'Estimating the Effect of Student Aid on College Enrollment: Evidence from a Government Grant Policy Reform', *American Economic Journal: Economic Policy*, vol. 2(2), pp. 185-215.

Rothstein, J. and Rouse, C. E. (2011). 'Constrained After College: Student Loans and Early-career Occupational Choices', *Journal of Public Economics*, vol. 95, pp. 149-163.

SLC (2016), 'Student Loans - Average Loan Balance on Entry into Repayment', Student Loans Company.

Sjoquist, D. L. and Winters, J. V. (2015a). 'State Merit-Aid Programs and College Major: a Focus on STEM', *Journal of Labor Economics*, vol. 33(4), pp. 973-1006.

Sjoquist, D. L. and Winters, J. V. (2015b). 'The Effect of Georgia's HOPE Scholarship on College Major: a Focus on STEM', *IZA Journal of Labor Economics* 4:15.

UCAS (2012a). 'How have Applications for Full-time Undergraduate Higher Education in the UK Changed in 2012?', UCAS Analysis and Research.

UCAS (2012b). 'End of Cycle Report 2012', UCAS.

Universities UK (2009). 'Changing Landscapes: Future Scenarios for Variable Tuition Fees', research report March 2009.

Figure 1. Changes in tuition fees in England and Scotland

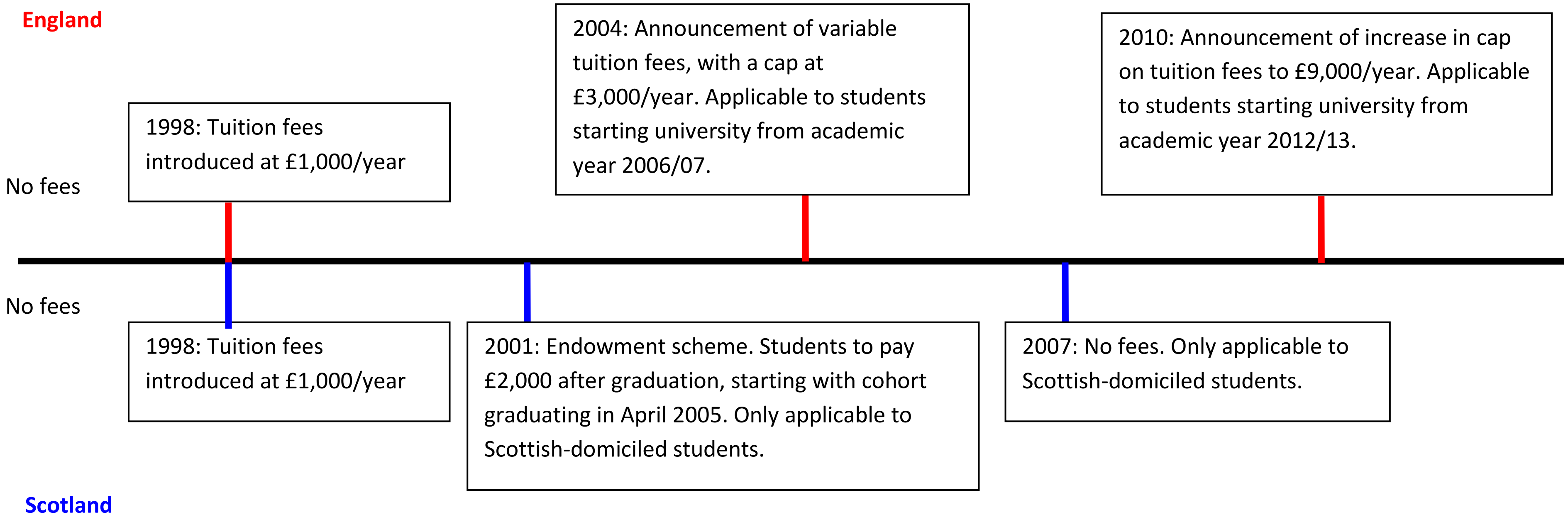
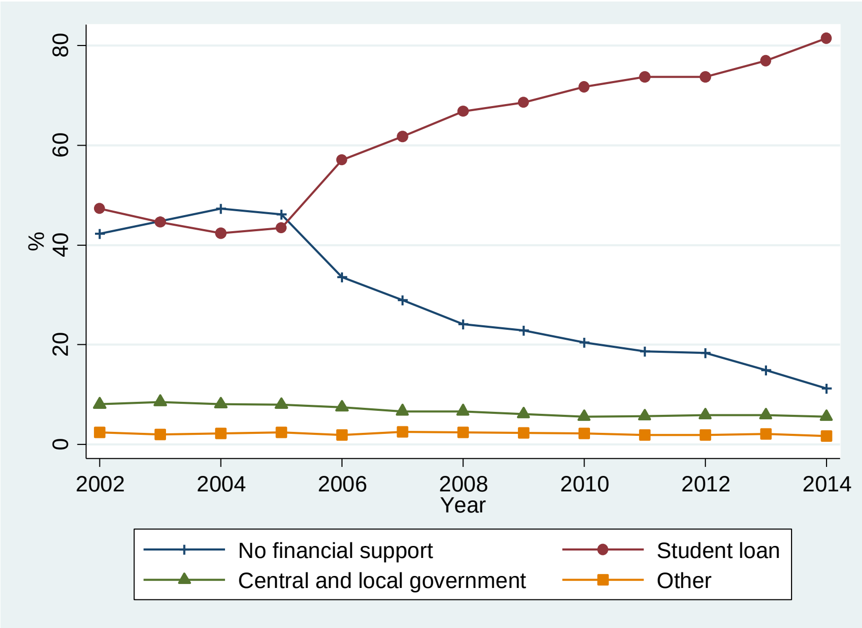
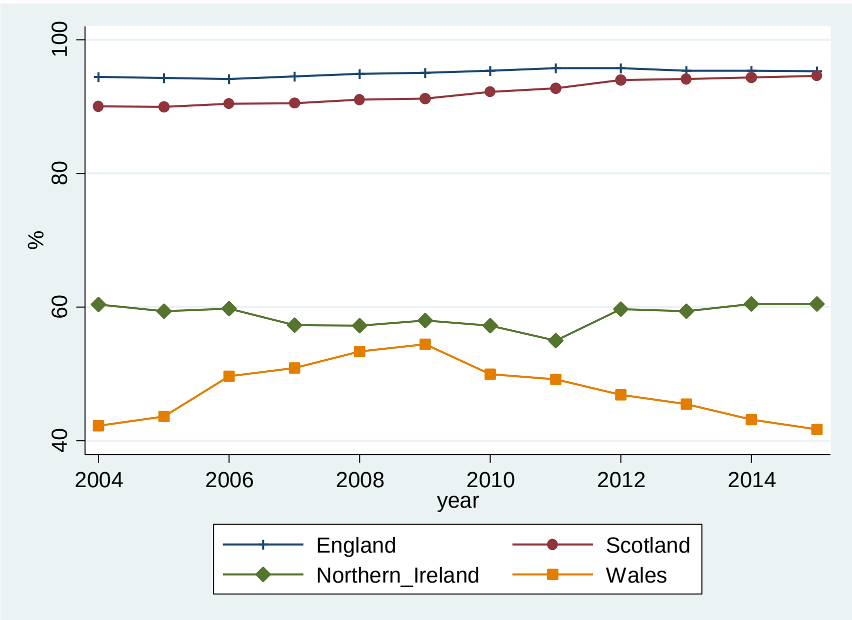


Figure 2. Percentage of undergraduate students with domicile in England attending English institutions by main source of financial support for payment of tuition fees



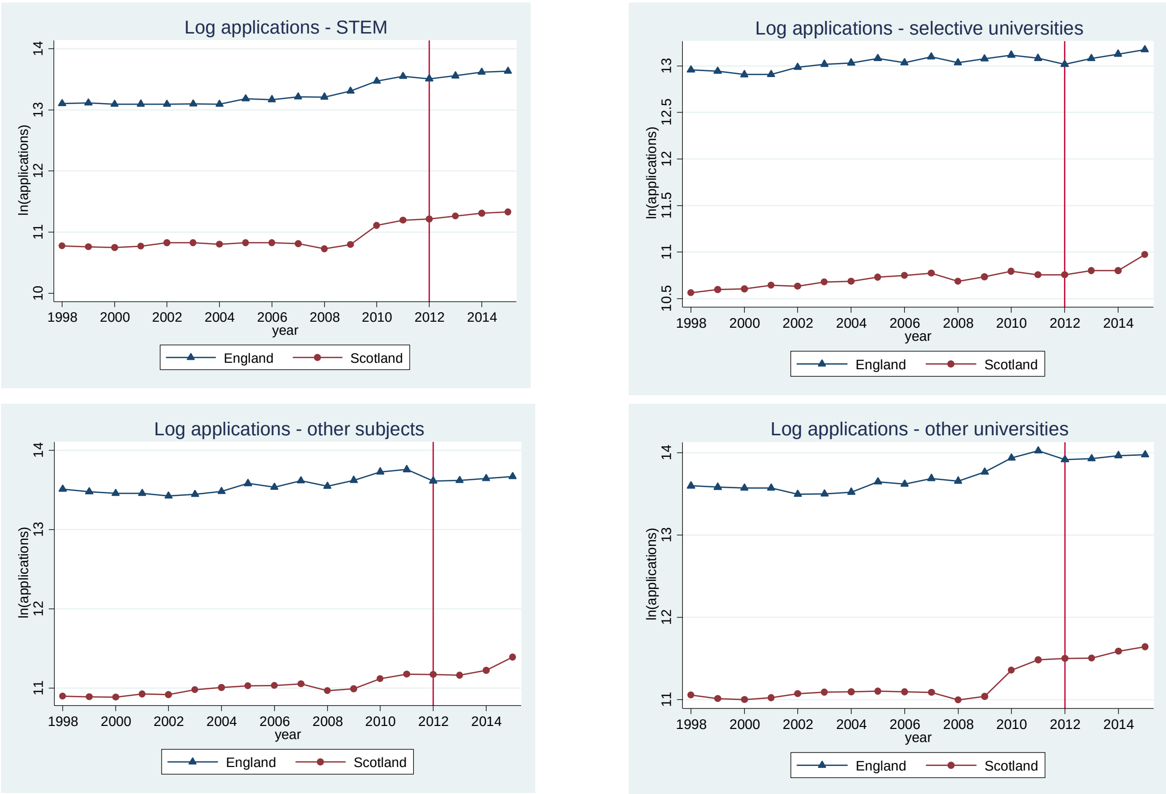
Source: HESA student database.

Figure 3. Percentage of applications to institutions in the applicant's home country by country of domicile



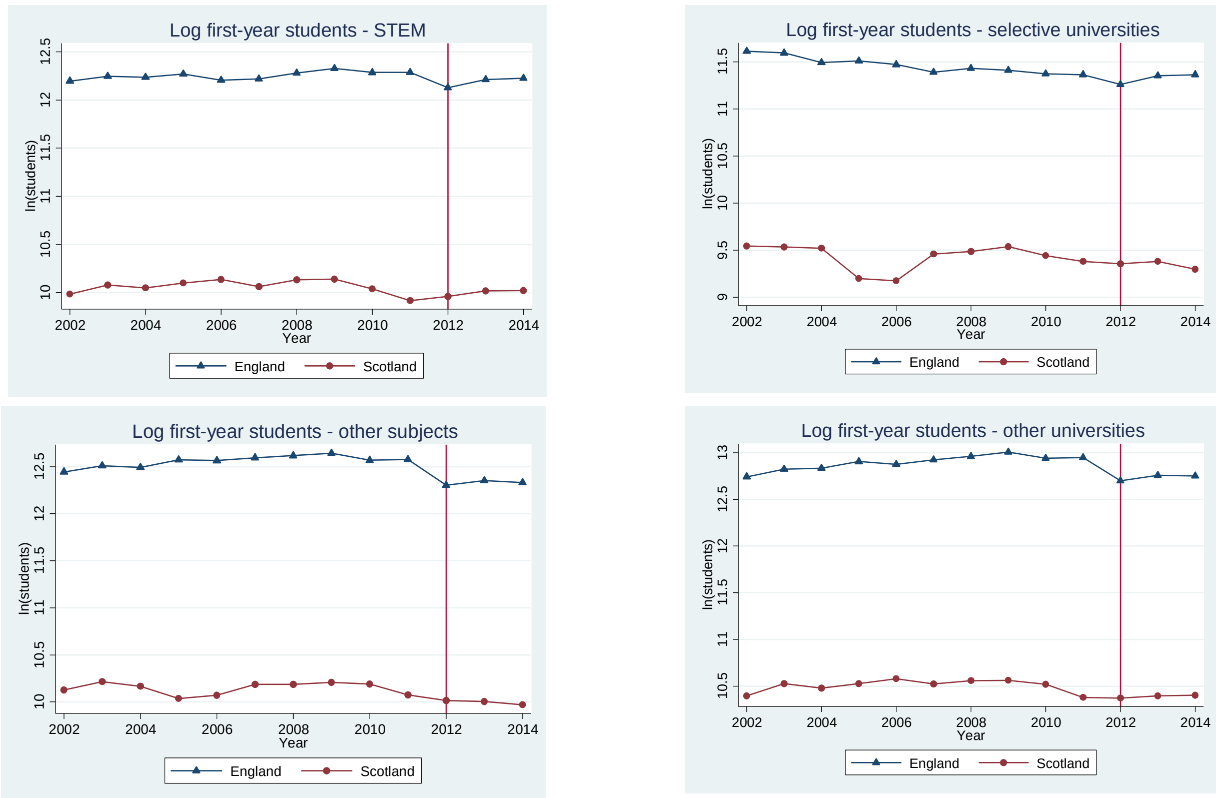
Source: UCAS.

Figure 4. Log number of applications by country of domicile



Source: UCAS.

Figure 5. Log number of first-year undergraduates by country of domicile



Source: HESA student database.

Table 1. Changes to student funding in England in 2012

	Students first enrolled in 2011–12	Students first enrolled in 2012–13
Fees	£3,375 in 2011; £3,465 in 2012, as announced; assumed to stay at £3,465 thereafter.	Up to £9,000 a year.
Student support		
Fee loan	All students may get a loan from the Student Loans Company (SLC) to pay the fees and must repay SLC after they graduate.	All students may get a loan from the Student Loans Company (SLC) to pay the fees and must repay SLC after they graduate.
Maintenance grant	In 2011, £2,906 if household income less than or equal to £25,000 p.a. Tapered away at 20% withdrawal rate for income between £25,000 and £34,000. Tapered away at around 7% withdrawal rate between £34,000 and £50,020. The maximum grant, the means-testing thresholds and the taper rates changed slightly for subsequent years.	In 2012, £3,250 if household income less than or equal to £25,000 p.a. Tapered away at around 18% withdrawal rate thereafter. No grant available when parental income exceeds £42,600. The maximum grant increases slightly in subsequent years.
Maintenance loan	The maximum loan is £3,838 for students living at home, £4,950 for others outside London, and £6,928 for those away from home and in London. The maximum loan is lower for the final year of study. Students lose 50p maintenance loan for every £1 they receive as maintenance grant. The loan is tapered away at 20% for household income above £50,778. All students are guaranteed at least 72% of the maximum loan. The parameters did not change in cash terms between 2011 and 2013.	The maximum loan is £4,375 for students living at home, £5,500 for others outside London, and £7,675 for those away from home and in London. The maximum loan is lower for the final year of study. Students lose 50p maintenance loan for every £1 they receive as maintenance grant. The loan is tapered away at 10% for household income above £42,875. All students are guaranteed at least 65% of the maximum loan. The parameters did not change in cash terms between 2012 and 2013.
Other student support	Universities have their own schemes. They are obliged to pay a minimum of 10% of fees to students who receive the maximum maintenance grant.	The National Scholarship Programme (NSP) was introduced to give at least £3,000 each to low-income students. Eligibility requires household income to be no more than £25,000. The award may be given as fee waivers. Universities determine the detailed criteria. Not all eligible students are guaranteed an award. The NSP has since been abolished for undergraduates.
Accumulation and repayment of student loans		
Real interest rate (relative to RPI)		
During study	0%	3%
After graduation	0%	0–3% depending on graduate income: 0% if below the repayment threshold, linearly increasing to 3% for income at or above the higher repayment threshold
Repayment rate	9%	9%
Repayment threshold	£15,795 in 2012 (above which 9% of income is to be paid)	£21,000 in 2016 (above which 9% of income is to be paid)
Higher repayment threshold	n.a.	£41,000 in 2016 (at which point the real interest rate is 3%)
Threshold indexation	Annually in line with RPI from 2012	Annually in line with national average earnings from 2017
Repayment period	25 years	30 years

Source: Reproduced from Crawford and Jin (2014), Table 2.1.

Table 2. Log number of applications and students by country of domicile

	Log applications		Log students	
	England	Scotland	England	Scotland
2008	14.086	11.546	13.214	10.864
2009	14.171	11.592	13.246	10.878
2010	14.301	11.807	13.186	10.820
2011	14.352	11.877	13.193	10.697
2012	14.256	11.887	12.970	10.686
2013	14.283	11.906	13.019	10.710
2014	14.324	11.961	13.022	10.694
2015	14.345	12.054		
Difference 2014/15 - 2011	-0.006	0.177	-0.171	-0.003
Difference-in-differences	**-0.184**		**-0.169**	

Table 3. Initial estimates

	Log applications			Log students		
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment group × post treatment	-0.207***	-0.263***		-0.115***	-0.197***	
	(0.002)	(0.004)		(0.000)	(0.003)	
Treatment group × 2010			0.026			0.017
			(0.007)			(0.003)
Treatment group × 2011			-0.001			0.074*
			(0.019)			(0.007)
Treatment group × 2012			-0.218*			-0.133**
			(0.022)			(0.005)
Treatment group × 2013			-0.237**			-0.065**
			(0.009)			(0.003)
Treatment group × 2014			-0.182***			-0.079**
			(0.000)			(0.002)
Treatment group × 2015			-0.172**			
			(0.006)			
Observations	98,691	98,691	98,691	71,711	71,711	71,711
R-squared	0.191	0.191	0.191	0.153	0.153	0.153
Country-specific trends	No	Yes	No	No	Yes	No

Notes. Robust standard errors clustered by country in parentheses. Critical values calculated for a T(1) distribution to account for a small number of clusters. Regressions include year and country of domicile fixed effects, the log of population, and indicators for gender and age group. Leads and lags of the reform (Treatment group × year) are equal to one in the year indicated for students with domicile in England and zero otherwise. *** significant at 1%, ** significant at 5%, * significant at 10%.

Table 4. Average salaries and employment rates six months after graduation 2011/12

Subject	Average salary (£)	Average employment rate (%)
Medicine and dentistry	28,988	92
Engineering and technology	24,028	63
Mathematical and computer sciences	21,922	57
Architecture, building and planning	21,451	69
Subjects allied to medicine	20,728	66
Business and admin. studies	19,804	60
Social studies	19,765	50
Education	19,403	64
Physical sciences	19,123	43
Veterinary science and agricultural and related studies	19,090	60
Law	17,926	35
Historical and philosophical studies	17,323	40
Languages	17,266	45
Biological sciences	17,021	42
Mass communications and documentation	16,581	55
Creative arts and design	16,051	48
STEM subjects	20,875	56
Non-STEM subjects	18,368	51
Selective universities	21,682	51
Other universities	18,477	53

Source: HESA DLHE survey.

Note: Average salaries calculated for workers age 20 to 30 in full-time paid employment (including self-employment) earning less than £60,000 per year six months after graduation. Employment rate is the share of the population of graduates in full-time paid employment six months after graduation. Selective universities are the ones included in the Sutton Trust 30 group: Bath, Birmingham, Bristol, Cambridge, Durham, Edinburgh, Exeter, Glasgow, Imperial College, King's College London, Lancaster, Leeds, Leicester, Liverpool, London School of Economics, Manchester, Newcastle, Nottingham, Oxford, Reading, Royal Holloway, Sheffield, Southampton, St Andrews, Strathclyde, Surrey, University College London, Warwick and York.

Table 5. Differences by expected salary and employment rate after graduation

	Log applications		Log students	
	By salary quartile	By employment quartile	By salary quartile	By employment quartile
	(1)	(2)	(3)	(4)
Treat × post × Q1	-0.248	-0.310	-0.163*	-0.203
	(0.049)	(0.155)	(0.015)	(0.069)
Treat × post × Q2	-0.246*	-0.132	-0.209*	-0.141
	(0.030)	(0.137)	(0.023)	(0.065)
Treat × post × Q3	-0.223*	-0.140	-0.125	-0.157*
	(0.021)	(0.054)	(0.043)	(0.024)
Treat × post × Q4	-0.114	-0.150	-0.119*	-0.152
	(0.093)	(0.026)	(0.010)	(0.033)
Observations	67,494	50,481	51,291	38,985
R-squared	0.294	0.354	0.225	0.279

Notes. Robust standard errors clustered by country in parentheses. Critical values calculated for a T(1) distribution to account for a small number of clusters. Regressions include year and country of domicile fixed effects, the log of population, and indicators for gender, age group and salary/employment rate quartile. Columns (1) and (3) report coefficients on the treatment indicator interacted with an indicator for each quartile of the distribution of expected average salaries of graduates in full-time paid employment six months after graduation. Columns (2) and (4) report coefficients on the treatment indicator interacted with an indicator for each quartile of the distribution of expected average employment rates of graduates six months after graduation. *** significant at 1%, ** significant at 5%, * significant at 10%.

Table 6. Differences by subject and type of institution

	Log applications		Log students	
	By subject	By institution	By subject	By institution
	(1)	(2)	(3)	(4)
Treat × post × STEM	-0.099**		-0.051	
	(0.002)		(0.026)	
Treat × post × nonSTEM	-0.279**		-0.155*	
	(0.005)		(0.016)	
Treat × post × selective		-0.089		-0.084***
		(0.209)		(0.000)
Treat × post × other		-0.247		-0.125***
		(0.074)		(0.001)
Observations	98,691	98,691	71,711	71,711
R-squared	0.192	0.192	0.154	0.158

Notes. Robust standard errors clustered by country in parentheses. Critical values calculated for a T(1) distribution to account for a small number of clusters. Regressions include year and country of domicile fixed effects, the log of population, and indicators for gender, age group and salary/employment rate quartile. Columns (1) and (3) report coefficients on the treatment indicator interacted with an indicator for STEM and non-STEM subjects. Columns (2) and (4) report coefficients on the treatment indicator interacted with an indicator for selective universities and other universities. *** significant at 1%, ** significant at 5%, * significant at 10%.

Table 7. Effect on attendance by level of participation in higher education in local authority

	Log students	
	Low participation	High participation
Treatment group × post treatment	-0.166***	-0.317***
	(0.001)	(0.001)
Observations	12,700	13,882
R-squared	0.156	0.129

Notes. Robust standard errors clustered by country in parentheses. Critical values calculated for a T(1) distribution to account for a small number of clusters. Regressions include year and country of domicile fixed effects, the log of population, and indicators for gender and age group. Local authorities are divided into two groups by the median rate of participation in higher education of people who reached age 18 between 2005 and 2009 (POLAR 3 data from HEFCE).

Table 8. Effect on attendance by ethnicity

	Log students			
	White	Black	Asian	Other
Treatment group × post treatment	-0.333**	-0.000	-0.056**	0.016
	(0.010)	(0.005)	(0.003)	(0.004)
Observations	14,183	7,779	8,629	8,149
R-squared	0.181	0.077	0.192	0.190

Notes. Robust standard errors clustered by country in parentheses. Critical values calculated for a T(1) distribution to account for a small number of clusters. Regressions include year and country of domicile fixed effects, the log of population, and indicators for gender and age group.

Table 9. Effect on applications and attendance by gender

	Log applications		Log students	
	(1)	(2)	(4)	(5)
I. Women				
Treatment group × post treatment	-0.237**	-0.302***	-0.137***	-0.195*
	(0.006)	(0.002)	(0.002)	(0.021)
Observations	49,424	49,424	35,874	35,874
R-squared	0.199	0.199	0.158	0.158
II. Men				
Treatment group × post treatment	-0.198**	-0.233***	-0.088**	-0.137***
	(0.013)	(0.002)	(0.002)	(0.001)
Observations	49,267	49,267	35,837	35,837
R-squared	0.185	0.185	0.147	0.148
Country-specific trends	No	Yes	No	Yes

Notes. Robust standard errors clustered by country in parentheses. Critical values calculated for a T(1) distribution to account for a small number of clusters. Regressions include year and country of domicile fixed effects, the log of population, and indicators for age group. *** significant at 1%, ** significant at 5%, * significant at 10%.

Table 10. Effect on applications – full sample

	Log applications		
	Baseline	By subject	By institution
	(1)	(2)	(3)
Log fees	-0.356**		
	(0.010)		
Log fees × STEM		-0.355**	
		(0.010)	
Log fees × nonSTEM		-0.358**	
		(0.010)	
Log fees × selective			-0.334***
			(0.004)
Log fees × other			-0.360**
			(0.012)
Observations	196,048	196,048	196,048
R-squared	0.220	0.220	0.225

Notes. Robust standard errors clustered by country in parentheses. Critical values calculated for a T(1) distribution to account for a small number of clusters. Regressions include year and country of domicile fixed effects, the log of population, and indicators for gender and age group. Column (2) reports coefficients on the log of fees interacted with an indicator for STEM and non-STEM subjects. Column (3) reports coefficients on the log of fees interacted with an indicator for selective universities and other universities. *** significant at 1%, ** significant at 5%, * significant at 10%.